

BELLCOMM, INC.

SUBJECT: Airesearch Block II ECS Critical
Design Review, January 3-6 -
Case 330

DATE: January 12, 1967

FROM: T. A. Bottomley, Jr.

ABSTRACT

A subcontractor Critical Design Review was held at Los Angeles, on January 3-6 to evaluate the design of Airesearch's part of the Block II CM Environmental Control System (ECS).

The following were the results of this review:

1. Design definition was completed for use as a baseline for formal Block II ECS configuration control.
2. The major configuration changes recommended for design review included:
 - a. change from automatic to manual control of the cabin heat exchanger,
 - b. substitution of Gemini-type Vernatherm valve for the motor-driven glycol mixing valve and associated control circuit,
 - c. provision of spring-loaded oxygen check valves and redesign of the oxygen shut-off valve to protect against dumping reentry oxygen after SM separation.
3. The major problems are related to ECS instrumentation (including control circuits) design and the development of suitable water tank bladders and glycol pump accumulators.
4. Qualification testing of Block II components is falling behind an "already-tight" schedule by 1 to 2 months.

MSC has initiated an in-house review of the Block II ECS instrumentation and related control circuitry to assess the adequacy of the design for manned flight.

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MEMORANDUM FOR FILE

1.0 INTRODUCTION

A subcontractor Critical Design Review (CDR) was held at Los Angeles on January 3 through January 6 to review the detailed design and performance characteristics of that portion of the Block II Command Module Environmental Control System (ECS) subcontracted to the Airesearch Corporation.

The review board was composed of the following members:

J. P. Harrington - NAA/Apollo Configuration Manager
(Chairman)

R. E. Sexton - NAA/ECS Project Manager

F. H. Samonski - NASA/ECS Project Manager

C. Clarke - Airesearch/ECS Project Manager

The result of the review was design definition of the Airesearch ECS product which will be used as a baseline for subsequent formal configuration management.

2.0 DOCUMENTATION

Drafts of the meeting minutes and documentation covering Block I and Block II ECS configuration differences were obtained as listed in Appendix A.

3.0 CONFIGURATION CHANGES

The major ECS Configuration changes approved by the board for analysis and feasibility assessment were:

- a. the substitution of manual for automatic control of the cabin heat exchanger (Item 3.2),
- b. substitution of the Gemini-type Vernatherm valve for the motor-driven glycol mixing valve (Item 2.42) and associated control circuit,

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R. A. Bottomley, Jr. Only

- c. provision of spring-loaded check valves and oxygen shut-off valves (Items 4.25 and 4.26) to preclude overboard dumping of reentry oxygen after SM separation.

4.0 MAJOR PROBLEM AREAS

The most significant problems areas, from the point of view of the possible necessity for redesign and uncertainty as to future courses of action, appeared to be the following:

4.1 Bladder Development

Bladder failures have been experienced in the waste tank (008), portable water tank, (Group 1 Qual) supplemental water tank (008), and the glycol reservoir (008 and Group 1 Qual). Failures have been traced to faulty assembly, weld protruberances, improper charging procedures, and failure during cyclic testing. Failure of bladders under cyclic testing is still unresolved. The following facts apply:

- a. Bladder material is polyisoprene. Tensile strength and elongation characteristics are drastically reduced above 150°F.
- b. Test history is as follows:

<u>Water Temp.</u>	<u>Tank Temp. (Approx.)</u>	<u>Failed At</u>
170°F max.	155°F	47 cycles (1 cph)
153°F max.	147°F	70 cycles (1 cph)
135°F	135°F	135 cycles (1 cph)
80°F	150°F	(No failure at 1,200 cycles - 4 cph) testing still in progress.)
100°F	135°F	(No failure after 50 cycles - 1 cph) testing still in progress.)

- c. Test requirements - cyclic testing:

No. of cycles = 600 x N (where N equal the number of cycles anticipated during the mission but not less than 2,500 cycles).

Temperature environments:

Water = 165°F maximum

Ambient = 135°F maximum.

The most critically affected component is the Potable Water Tank (Item 5.10) which is the primary reservoir for fuel cell water delivered at approximately 160°F. Airesearch is continuing a material search but has not yet found a suitable substitute.

4.2 Bellows Development

The Glycol Pump Assembly (Item 2.48) contains an integral accumulator having metal bellows which compensate for thermal expansion and contraction of the coolant, and maintain positive pump inlet pressure to ensure proper pump operation.

The Block II bellows require proof pressure testing at 90 psi (versus 50 psi for Block I) and have a non-linear position relationship to the glycol quantity in the accumulator. Airesearch believes that they will be unable to provide a bellows which will meet proof pressure and linearity characteristic requirements under existing cyclic test specifications.

4.3 Instrumentation

Difficulty has been experienced in maintaining sensors in calibration and in providing proper automatic control operation of ECS component assemblies. Redesign is contemplated by Airesearch for a number of sensors which are subject to calibration changes due to diaphragm shift, inadequate hermetic sealing, inadequate thermal and electromagnetic radiation protection, and low insulation resistance.

Discussions with personnel from Airesearch, NAA and NASA developed the consensus that certain ECS instrumentation design is behind the state-of-the-art (e.g., use of copper rather than platinum) as a sensing element, exposure of bridge network resistances to wide temperature variations, failure to provide compensation circuitry to maintain calibration, etc.). In addition, NAA Instrumentation Specifications, which were complied with by Airesearch in both Block I and Block II ECS systems, require grounding wiring shields at both ends. North American stated that these grounding requirements were poor practice and might compromise measurements. With the exception of the Glycol Evaporator Temperature Control Circuit (Item 2.40), it was MSC's opinion that the ECS instrumentation would be adequate for flight, provided that the required sensors were carefully selected.

In view of existing problems and the complexity of the circuitry, Mr. Samonski, CM ECS Project Manager, has initiated an in-house review of the Block II Environmental Control System instrumentation. Mr. Stig Ekeroot, Crew Systems Division, is making the analysis with his initial efforts concentrated on evaluation of the Glycol Evaporator Temperature Control design.

4.4 ECS Test Program

Block II Qualification testing at the Group 1 (component) level was 82% complete as of December 19, 1966. This was 8% below AiResearch's objective for the same date. Extrapolation along the test completion schedule suggests that Group 1 Qualification testing will slip one to two months beyond the objective for 100% completion by March 1, 1967.

F. H. Samonski

2031-TAB-sam

for T. A. Bottomley, Jr.

Attachment
Appendix A

Copy to

Messrs. L. E. Day - NASA/MAT
C. C. Gay - NASA/MAT
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T. A. Keegan - NASA/MA-2
A. F. Phillips - NASA/MAT
M. L. Seccomb - NASA/MAP
J. H. Turnock - NASA/MA-4
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APPENDIX A

Block I and Block II ECS Documentation

1. The following Block II documentation was obtained:
 - (1) Plan of Action - CDR (NAA letter) - 12/19/66.
 - (2) ECS Baseline Configuration - 12/16/66.
 - (3) ECS Hardware Documentation Matrix - 1/3/67.
 - (4) ECS Group 1 Qual Test Schedule and Status as of 12/19/66.
 - (5) Minutes of CDR Meetings (Drafts) - 1/3 - 5/67.
 - (6) Board Review Minutes (Draft) - 1/4/67.
 - (7) ECS Component Failure History Review (Draft) 12/16/66.
 - (8) ECS Criticality I Single Point Failure Components (Informal Note from NAA).

2. The following Block I documentation was also obtained:
 - (1) ECS Configuration Matrix (Sys. #1 - #11 covering Block I test and flight vehicles).
 - (2) ECS Configuration Retrofit (SC 012, 012 spare, 017, and 020).
 - (3) SC 012 ECS Design Review - NAA letter dated 12/8/66. (Summarizing design review findings).
 - (4) SC 012 ECS Design Review - NAA letter dated 12/29/66. (Listing actions required by Airesearch).